# Effects of Concomitant Spinal Cord Injury and Brain Injury on Medical and Functional Outcomes and Community Participation

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**Background:** There are limited data on the interactions between concomitant spinal cord injury (SCI) and traumatic brain injury (TBI) in terms of medical, psychological, functional, and community outcomes. **Objective:** To investigate the hypothesis that in addition to SCI-associated sensory-motor impairments, people with dual diagnosis would experience additional TBI-associated cognitive impairments that would have a negative impact on community reintegration. **Methods:** Cross-sectional, case-matched study comparing a consecutive sample of participants with dual diagnosis ($n$ = 30) to an SCI group ($n$ = 30) and TBI group ($n$ = 30). Participants who were on average 3.6 years postrehabilitation discharge were interviewed using a battery of standardized outcome measures. **Results:** Length of rehabilitation stay was significantly longer in SCI and dual diagnosis participants. Fatigue, pain, sexual dysfunction, depression, and sleep disturbances were frequently reported by all groups. Similar levels of anxiety and depression were reported by participants in all groups, however TBI participants reported higher stress levels. All groups achieved mean FIM scores > 100. The dual diagnosis and SCI groups received more daily care and support than TBI participants. Similar levels of community reintegration were achieved by all groups with a high level of productive engagement in work, study, or volunteer activities. **Conclusions:** The findings of this study do not support the hypotheses. Postrehabilitation functioning was better than anticipated in adults with dual diagnosis. The contribution of rehabilitation factors, such as longer admission time to develop compensatory techniques and strategies for adaptation in the community, may have contributed to these positive findings.
**Key words:** *community participation, functional outcomes, rehabilitation, spinal cord injuries, traumatic brain injuries*

The reported incidence of concomitant spinal cord injury (SCI) and traumatic brain injury (TBI) (hereafter termed *dual diagnosis*) varies between studies. Literature from the last 40 years reports incidence rates from 16% to 59%.[1,2] The marked variability in these rates results from differences in sample populations and varying diagnostic methods.[1] In other studies, dual diagnosis may remain undiagnosed.[1,3]

Although the frequency of concomitant SCI and TBI is high, few studies have compared the rehabilitation outcomes of individuals with dual diagnosis to those with single diagnosis SCI. There is no identifiable research comparing dual diagnosis to TBI. Studies comparing dual diagnosis and single diagnosis SCI during acute and inpatient rehabilitation have generally indicated lower motor and cognitive FIM[4] scores for people with dual diagnosis[5,6] and greater clinical resource utilization by patients in the dual diagnosis group.[6] Recent findings have challenged these outcomes by identifying a potential interaction of co-occurring TBI severity and level of SCI. In a prospective study of 189 adults with SCI, tetraplegia with co-occurring TBI was not related to FIM motor outcomes despite cognitive impairments. Further,

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in adults with paraplegia, only presence of severe TBI impacted FIM motor outcomes, whereas presence of mild or moderate TBI did not appear to impact motor outcomes.[7]

When considering postrehabilitation outcomes, it has been speculated that the addition of TBI in people with SCI will exacerbate adjustment and behavior difficulties, possibly leading to social isolation.[8] One examination of community outcomes reported that people with dual diagnosis experienced greater personal and family adjustment difficulties than matched individuals with SCI.[9] Factors associated with community integration and participation in single diagnosis SCI or TBI include environmental barriers,[10-12] social context,[11,13-15] severity of brain injury,[14,16] challenging behavior,[16] and level of disability.[16,17] It is hypothesized that these factors along with the previously reported motor and cognitive deficits in adults with dual diagnosis would lead to poorer community reintegration. This may have significant implications when planning services for people with dual diagnosis, considering their additional health care needs or increased care and support requirements. The current research aimed to evaluate this hypothesis by comparing the medical, psychological, functional, and community outcomes of adults with dual diagnosis during the first several years post discharge from rehabilitation.

## Methods

Ethics approval for this cross-sectional, individual case-matched cohort study was granted by the Human Research Ethics Committees of Northern Sydney Health, The University of Sydney, and Macquarie University. All procedures were conducted in accordance with these ethical standards. Consent was gained from all participants or a person legally responsible for decision making.

### Participant recruitment: Dual diagnosis

Consecutive discharges ($n$ = 204) from a specialist SCI rehabilitation service from January 1, 2003 to June 30, 2009 were screened against the following criteria: (1) first incidence of traumatic SCI with reported concomitant TBI and (2) age between 17 and 75 years at the time of injury. Electronic database screening of discharges positively identified 36 patients who were classified as dual diagnosis. Hand searching of the remaining 168 medical records was conducted to identify any cases of undiagnosed concomitant TBI. An additional 39 patients were positively classified as dual diagnosis when the acute medical record or ambulance report included one or more of the following indicators: loss of consciousness at scene of accident, Glasgow Coma Scale[18] (GCS) score less than 15, or abnormal brain imaging. Neuropsychological evaluation (when available) was used to confirm presence of cognitive impairment. In 204 traumatic SCI discharges, 75 (37%) were classified as dual diagnosis, of which 33 consented to participate and 30 were case-matched to single diagnosis TBI and SCI.

### Participant recruitment: Single diagnosis

Each dual diagnosis participant ($n$ = 30) was individually case-matched to one participant who had sustained a single diagnosis SCI ($n$ = 30) and one participant who had sustained a single diagnosis TBI ($n$ = 30). Single diagnosis participants were recruited from electronic databases managed by specialist SCI and TBI services in Sydney, Australia. All single diagnosis SCI participants were recruited from the same facility as the dual diagnosis participants. Adults with moderate, severe, and very severe injuries were recruited from a specialist TBI rehabilitation facility geographically located near the SCI rehabilitation facility. Mild TBI participants were admitted as inpatients and were managed by a tertiary trauma team at Westmead Hospital, Sydney.

Participants were first case-matched on injury severity indices. SCI participants were matched on neurological level of SCI (cervical, thoracic, lumbar) and on American Spinal Injury Association Impairment Scale (AIS) score.[19] TBI participants were matched on lowest GCS score (at injury or emergency admission) and duration of posttraumatic amnesia (PTA)[20] based on prospective assessment of PTA for severe to very severe TBI and retrospective assessment for those with mild TBI.[21] Next, individual dual diagnosis participants were case-matched to single diagnosis participants on age at injury and sex. Data were collected on additional potentially confounding factors including premorbid psychiatric history and premorbid drug and/or alcohol use, level of education, and time postrehabilitation discharge.

**Data collection and outcome measures**

Demographic data obtained from medical records included sex, age at injury, years of education, and relationship status at injury. Premorbid medical history, level of SCI, AIS, GCS score, PTA duration, and rehabilitation admission and discharge FIM scores were obtained from medical records, clinical reports, and databases.

Semi-structured interviews were conducted in the participant's home, at the medical center, or via telephone for remotely located participants. Medical status during the 12-month period preceding the interview was measured using the Secondary Conditions Questionnaire (SCQ).[22] Psychological functioning and behavior were measured using the Depression, Anxiety, and Stress Scale-21 (DASS-21)[23] and Overt Behaviour Scale.[24] Participants' ability to independently perform activities of daily living and their resulting care needs were measured using the FIM and the Care and Needs Scale (CANS).[25] Information about participants' social engagement and relationships was obtained using the Sydney Psychosocial Reintegration Scale (SPRS)[26] and a modified version of the Sexuality After Spinal Cord Injury Questionnaire.[27] Relationship status post injury was obtained at interview, as was engagement in productive occupations. This last variable was dichotomized into engaged in paid employment, volunteer work, or studying or not engaged in paid employment, volunteering, nor studying. Finally, participants' perceptions of environmental barriers were measured using the Craig Hospital Inventory of Environmental Factors (CHIEF)-short form.[28] (Additional information on outcome measures used is available in **Supplementary Appendix A** [doi: 10.1310/sci2003-225])

**Analysis**

All information was de-identified and analyzed using the Statistical Package for Social Sciences Version 20.0 (IBM SPSS, Armonk, NY). Descriptive statistics were calculated for demographic and injury-related variables to characterize the groups and evaluate group similarity on all case-matching variables. Data normality was tested using the Kolmogorov-Smirnov test and homogeneity of variance was evaluated using the Levene test. Three-way between-group analyses were performed using GLM analysis of variance (ANOVA), and the least significant difference pairwise comparisons were conducted post hoc when the overall ANOVA was significant. Ordinal level outcome measures and non-normally distributed data were analyzed using the Welch test for equality of means. Chi-square analyses were used to evaluate group differences on categorical outcome variables. The alpha level was adjusted for multiple between-group comparisons. Individual between-group differences were deemed significant at $P < .003$ in order to achieve an overall significance level of $P < .05$.

**Results**

The 3 groups were purposively matched at recruitment and did not differ on demographic variables (age, gender, years of education, relationship status; refer to **Table 1**). Reported preinjury psychiatric history was equally frequent between groups, however more participants with dual diagnosis reported preinjury drug and/or alcohol use. Group differences did not achieve statistical significance at the adjusted $P$ value ($\chi^2 = 9.14$, $P = .01$). Injury severity was well-matched, however mechanism of injury differed between groups. Small subgroup numbers did not permit statistical comparison, however assault was only evident in TBI participants and workplace injuries and falls primarily led to injury in dual diagnosis and SCI participants. Post hoc analysis identified that dual diagnosis participants remained in acute care longer than SCI participants (mean difference, 21 days; 95% CI = 0 to 41 days; $P = .05$) and 2 months longer than TBI participants (mean difference, 61 days; 95% CI = 41 to 82 days; $P < .001$). The rehabilitation stay of adults with dual diagnosis was similar to adults with SCI (mean difference, 7 days; 95% CI = -24 to 38 days). Both the dual diagnosis and SCI groups remained in rehabilitation more than 100 days longer than the TBI group (mean difference dual diagnosis/TBI, 117 days; 95% CI = 83 to 151 days; $P < 0.001$; mean difference SCI/TBI, 110 days, 95% CI = 75 to144 days; $P < .001$).

**Table 1.** Demographic, injury-related, and rehabilitation characteristics

| Variable | *n* | DDx | SCI | TBI | *F* or $\chi^2$ | *P* |
|---|---|---|---|---|---|---|
| *Demographic variables* | | | | | | |
| Age at injury[a], years | 90 | 39.3(13.2) | 42.8 (16.3) | 41.5 (13.5) | 0.44 | .645 |
| Sex[b], male:female | 90 | 26:4 | 29:1 | 24:6 | 3.94 | .140 |
| Education[a], years | 90 | 12.0 (3.1) | 12.4 (2.8) | 12.5 (3.2) | 0.23 | .794 |
| Relationship status at injury[b] | 90 | | | | 3.45 | .486 |
| Single | | 11 | 9 | 11 | | |
| Married/cohabiting | | 15 | 19 | 13 | | |
| Separated | | 4 | 2 | 6 | | |
| *Preinjury comorbidities* | | | | | | |
| Psychiatric history[b] | 89 | 6 | 9 | 6 | 1.32 | .517 |
| Drug/alcohol history[b] | 90 | 12 | 8 | 2 | 9.14 | .010 |
| *Injury-related variables* | | | | | | |
| Mechanism of injury | 90 | | | | | |
| Motor vehicle/aircraft accident | | 18 | 10 | 17 | | |
| Falls and sport | | 10 | 15 | 9 | | |
| Assault | | 0 | 0 | 4 | | |
| Workplace injury | | 2 | 3 | 0 | | |
| Other | | 0 | 2 | 0 | | |
| AIS level[b] | 60 | | | | 1.33 | .721 |
| A | | 15 | 12 | | | |
| B | | 3 | 6 | | | |
| C | | 5 | 5 | | | |
| D | | 7 | 7 | | | |
| SCI level[b] | 60 | | | | 0.00 | 1.00 |
| Cervical | | 10 | 10 | | | |
| Thoracic | | 16 | 16 | | | |
| Lumbar | | 4 | 4 | | | |
| PTA code[b] | 58 | | | | 2.32 | .314 |
| Mild (≤1day) | | 8 | | 6 | | |
| Moderate (1-7 days) | | 2 | | 0 | | |
| Severe (> 7 days) | | 20 | | 22 | | |
| GCS range[b] | 57 | | | | 1.66 | .435 |
| 13-15 | | 20 | | 18 | | |
| 9-12 | | 3 | | 7 | | |
| 3-8 | | 4 | | 5 | | |
| *Rehabilitation-related variables* | | | | | | |
| Length of stay[a], days | | | | | | |
| Acute | 90 | 94 (47) | 73 (32) | 33 (40) | 18.18 | .001 |
| Rehabilitation | 82 | 148 (72) | 141 (68) | 31 (22) | 27.72 | .001 |
| FIM score[a] | | | | | | |
| Rehabilitation admission | | | | | | |
| Total | 81 | 73.9 (20.2) | 77.1 (20.8) | 74.1 (24.3) | 0.21 | .815 |
| Motor | 75 | 41.2 (17.3) | 41.0 (20.0) | 53.8 (20.9) | 3.30 | .043 |
| Cognitive | 75 | 32.7 (6.1) | 34.8 (0.5) | 20.3 (5.9) | 55.77 | .001 |
| Rehabilitation discharge | | | | | | |
| Total | 81 | 97.1 (21.1) | 98.7 (19.9) | 109.1 (10.2) | 2.97 | .057 |
| Motor | 75 | 62.8 (20.8) | 64.6 (19.7) | 81.3 (9.6) | 7.37 | .001 |
| Cognitive | 75 | 34.3 (1.5) | 34.9 (0.34) | 27.9 (3.8) | 68.52 | .001 |

*Note:* Eight participants with mild TBI (PTA <1 day) are included in acute length of stay but not rehabilitation length of stay and do not contribute to the FIM scores reported above. AIS = American Spinal Injury Association Impairment Scale; DDx = dual diagnosis participant group; GCS = Glasgow Coma Scale; SCI = spinal cord injury; TBI = traumatic brain injury; PTA = posttraumatic amnesia (classification based on Corrigan et al[37]).

[a]Continuous variables are reported as mean (*SD*); analysis of variance group comparison (*F*).

[b]Categorical variables are reported as frequencies; chi-square group comparison ($\chi^2$).

Cognitive impairment in participants with dual diagnosis was not evident on FIM cognitive admission or discharge scores. Dual diagnosis participants achieved mean admission scores within 2 points of the SCI group and mean discharge score within 1 point of the SCI group and the FIM cognitive maximum score. The dual diagnosis group demonstrated significantly higher FIM cognitive scores than the injury severity matched TBI participants (mean difference, 12 points; 95% CI = 10 to 15 points; $P < .001$) at rehabilitation admission and discharge (mean difference, 6 points; 95% CI = 5 to 8 points; $P < .001$).

Participants with dual diagnosis achieved FIM motor scores equivalent to the SCI group at rehabilitation admission and discharge (mean differences less than 1 FIM point at admission and within 2 FIM points at discharge). The TBI group demonstrated significantly higher FIM motor scores than the dual diagnosis group at rehabilitation admission (mean difference, 12 points; 95% CI = 2 to 23 points; $P = .024$) and discharge (mean difference, 18 points; 95% CI = 8 to 29 points; $P = .001$).

### Medical outcomes

At the time of interview (mean [*SD*], 3.6 [2.1] years postrehabilitation discharge), all participants reported experiencing secondary medical conditions. The most commonly endorsed secondary medical conditions included fatigue, joint and muscle pain, sexual dysfunction, depression, and disturbed sleep (12 most frequently reported symptoms reported in **Table 2**). There were no statistical between-group differences in the overall reporting of secondary medical conditions as measured by the SCQ (see **Table 3**).

### Psychological outcomes

Stress and anxiety symptoms as measured by the DASS-21 were within normal range for the dual diagnosis and SCI and TBI groups. The TBI group tended to report higher levels of stress, however this difference in reporting did not reach statistical significance. The dual diagnosis group reported the lowest level of depressive symptoms, within the normal range, whereas participants in the SCI and TBI groups reported slightly higher depressive symptoms consistent with mild depression. Substantial within-group variability was evident, and between-group differences did not reach statistical significance. Participants with TBI displayed the highest number of overt challenging behaviors, however post hoc analysis identified that 95% confidence intervals cross zero for all paired comparisons, so differences are not statistically significant.

**Table 2.** Secondary medical conditions reported in the 12-month period prior to interview

| Secondary condition | DDx (*n*=30) | SCI (*n*=30) | TBI (*n*=30) | Overall (*n*=90) |
|---|---|---|---|---|
| Fatigue | 19 | 24 | 23 | 66 |
| Joint and muscle pain | 19 | 21 | 20 | 60 |
| Sexual dysfunction | 19 | 23 | 14 | 56 |
| Depression | 15 | 19 | 21 | 55 |
| Sleep disturbances | 20 | 18 | 16 | 54 |
| Bowel dysfunction | 21 | 25 | 6 | 52 |
| Bladder dysfunction | 20 | 23 | 8 | 51 |
| Chronic pain | 18 | 20 | 13 | 51 |
| Physical deconditioning | 17 | 18 | 16 | 51 |
| Muscle spasticity | 18 | 23 | 9 | 50 |
| Weight problems | 16 | 14 | 17 | 47 |
| Urinary tract infection | 17 | 22 | 6 | 45 |

*Note:* DDx = dual diagnosis participant group; SCI = spinal cord injury; TBI = traumatic brain injury.

### Functional outcomes

All groups achieved a mean FIM total score greater than 100 at interview, suggesting a moderate level of independent functioning. Evaluation of independence using the FIM demonstrated equivalent scores between the dual diagnosis and SCI groups, whereas the TBI group achieved significantly higher FIM total scores (mean difference TBI/dual diagnosis, 14 points; 95% CI = -1 to 29 points; $P = .006$; mean difference TBI/SCI, 15 points; 95% CI = 0 to 30 points; $P = .003$). The observed higher FIM total score was primarily due to higher FIM motor scores in the TBI group, as FIM cognitive scores did not differ

**Table 3.** Medical, psychological, functional, and community outcomes

| Outcomes | *n* | DDx | SCI | TBI | *F* or $\chi^2$ | *P* |
|---|---|---|---|---|---|---|
| Time from discharge to interview[a], years | 90 | 3.3 (2.1) | 3.9 (2.0) | 3.6 (2.2) | 0.50 | .606 |
| *Medical outcomes* | | | | | | |
| SCQ total[a] | 90 | 26.9 (13.6) | 28.3 (14.5) | 22.4 (14.1) | 1.44 | .242 |
| *Psychological outcomes* | | | | | | |
| DASS-21[b] | | | | | | |
| Stress subscale | 90 | 6.4 (7.9) | 7.2 (7.4) | 11.9 (10.9) | 2.63 | .081 |
| Anxiety subscale | 90 | 4.6 (4.8) | 5.8 (6.2) | 6.1 (9.2) | 0.52 | .597 |
| Depression subscale | 90 | 7.6 (11.9) | 9.5 (11.8) | 12.1 (13.0) | 1.00 | .375 |
| OBS[b] | 89 | 1.3 (2.4) | 0.5 (1.0) | 2.2 (3.7) | 3.53 | .038 |
| *Functional outcomes* | | | | | | |
| FIM Total[b] | 90 | 103.3 (21.6) | 102.4 (21.7) | 117.5 (13.4) | 7.63 | .001 |
| Motor | 90 | 70.3 (22.1) | 68.5 (21.5) | 86.9 (9.2) | 14.10 | .001 |
| Cognitive | 90 | 33.0 (2.7) | 34.0 (3.5) | 30.1 (6.1) | 3.24 | .047 |
| CANS level[b] | 88 | 2.2 (2.2) | 2.8 (2.2) | 1.5 (2.3) | 2.80 | .066 |
| *Community outcomes* | | | | | | |
| SPRS total[b] | 90 | 53.2 (11.8) | 55.0 (11.6) | 53.4 (13.4) | 0.21 | .808 |
| Part A: work & leisure | 90 | 14.8 (7.1) | 15.9 (6.9) | 14.9 (7.2) | 0.22 | .798 |
| Part B: relationships | 90 | 18.4 (4.7) | 19.7 (3.8) | 18.8 (4.0) | 0.88 | .419 |
| Part C: living skills | 90 | 20.0 (3.6) | 19.4 (4.2) | 19.7 (5.5) | 0.20 | .824 |
| Sexuality after injury questionnaire[a] | 76 | 12.0 (6.1) | 10.5 (7.8) | 6.8 (9.1) | 3.10 | .051 |
| Relationship status[c] | 90 | | | | | |
| Single | | 9 | 8 | 8 | 1.40 | .844 |
| Married/cohabiting | | 14 | 18 | 16 | | |
| Separated | | 7 | 4 | 6 | | |
| Employment[c] | 90 | | | | | |
| Not employed/studying | | 11 | 13 | 19 | 4.63 | .099 |
| Employed/studying | | 19 | 17 | 11 | | |
| CHIEF total[b] | 90 | 0.9 (0.9) | 0.8 (0.7) | 1.0 (1.1) | 0.21 | .813 |

*Note:* CANS = Care and Needs Scale; CHIEF = Craig Hospital Inventory of Environmental Factors; DASS-21 = Depression, Anxiety and Stress Subscale; DDx = dual diagnosis participant group; OBS = Overt Behaviour Scale; SCI = spinal cord injury; SCQ = Secondary Conditions Questionnaire; SPRS = Sydney Psychosocial Reintegration Scale; TBI = traumatic brain injury.

[a]Variables are reported as mean (*SD*); GLM analysis of variance (*F*).

[b]Variables are reported as mean (*SD*); Welch test for equality of means.

[c]Variables are reported as frequencies; chi-square test ($\chi^2$).

significantly between groups. Even though the cohort as a whole was functioning at a moderate level of independence, a wide range of care needs were recorded on the Care and Needs Scale. A bimodal distribution was evident for the dual diagnosis and SCI groups, whereas a unimodal distribution best represented the TBI group (see **Figure 1**). TBI participants predominantly reported living independently. Assistance was most commonly required for housework, using devices (eg, a telephone), and meal preparation. Higher levels of care and support needs were reported by dual diagnosis and SCI participants including assistance with housework, shopping, hygiene and continence management, transfers, bathing, and feeding.

### Community outcomes

All groups demonstrated similar levels of community reintegration as measured by the 3 subscales of the SPRS: Work and Leisure,

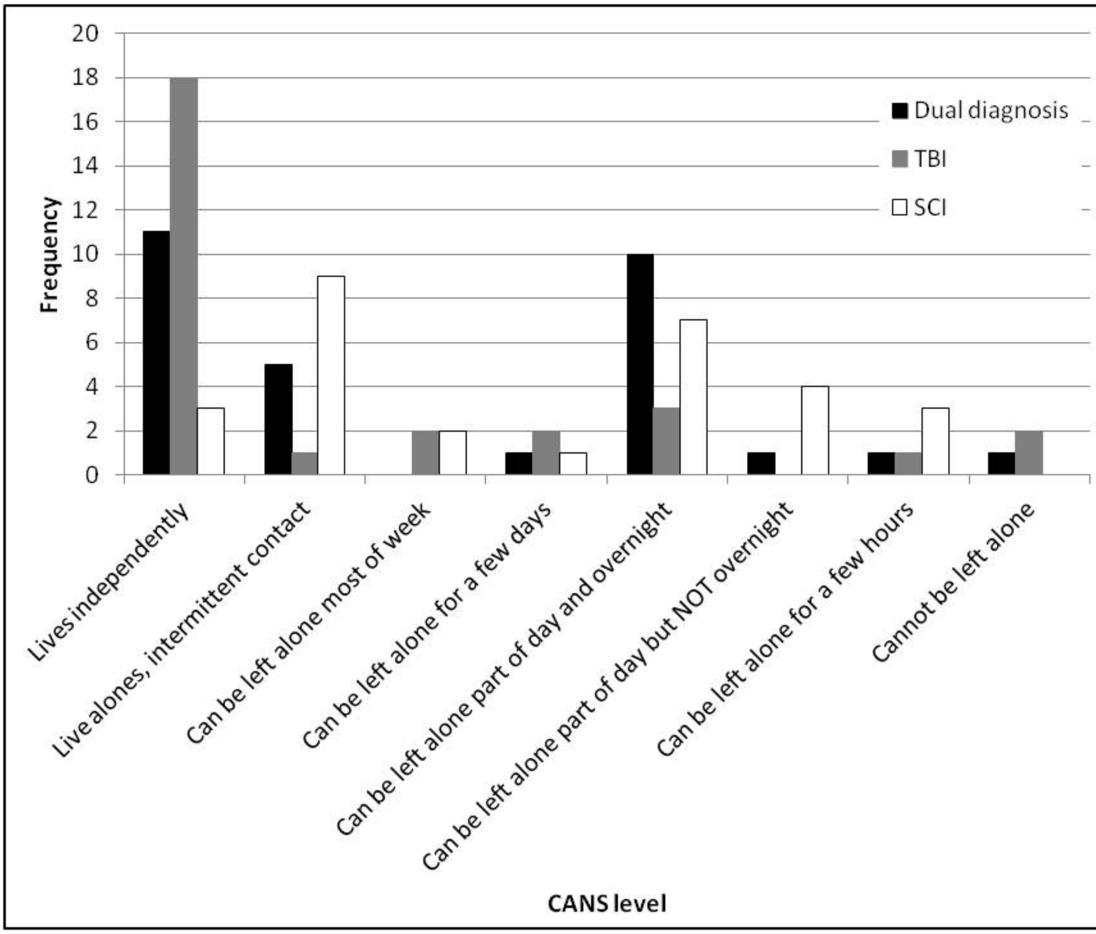


**Figure 1.** Comparison of Care and Needs Scale (CANS) scores between groups. SCI = spinal cord injury; TBI = traumatic brain injury.

Relationships, and Living Skills. Similar proportions of each group were in stable relationships. A small number of dual diagnosis and SCI participants had separated since their injury (dual diagnosis, 10% [*n*=3]; SCI, 6.7% [*n*=2]). No TBI participants had separated. Changes in sexuality after injury were calculated as the summed difference between preinjury and postinjury levels of sexual activity and satisfaction, hence larger values represent greater degree of change. In all groups, change led to reduced level of sexual activity and reduced satisfaction with sex post injury. Three-way between-group differences approached significance. Post hoc pairwise analysis identified this difference to lie between the dual diagnosis group (reporting greatest change) and the TBI group (reporting least change) (mean difference, 5 points; 95% CI = 1 to 9 points; $P = .017$).

A greater number of participants in the dual diagnosis and SCI groups were productively engaged in paid employment, volunteer work, or studying when compared to the TBI group, however these differences did not reach statistical significance. In general, a moderately high level of postinjury productive engagement was reported (dual diagnosis, 63% [*n*=19]; SCI, 57% [*n*=17]; TBI, 37% [*n*=11]). Perceptions of environmental barriers across the 5 CHIEF domains of policies, physical and structural, work and school, attitudes and support, and services and assistance did not differ between the 3 groups.

## Discussion

This case-matched cohort study examined differences in medical, psychological, functional, and community outcomes in adults with a dual diagnosis of SCI and TBI compared to a single diagnosis of SCI or TBI. The hypothesis underlying this research assumed that, in addition to SCI-associated sensory-motor impairments, people with dual diagnosis would experience TBI-associated cognitive impairments that would negatively impact community reintegration. The presence of concomitant SCI and TBI was hypothesized to have implications for service planning with regard to additional health care needs or increased care and support. These hypotheses were based on the extant literature at the time this study was begun, which suggested lower motor and cognitive functioning in people with dual diagnosis compared to SCI during rehabilitation[5,6] and greater clinical resource utilization by people with dual diagnosis.[6]

In general, the findings of this study do not support the hypotheses, presenting a postrehabilitation picture of higher function than is evident in previous studies of people with a dual diagnosis of SCI and TBI. At rehabilitation discharge, FIM motor and cognitive scores were comparable between the dual diagnosis and SCI groups. This finding supports recent acute rehabilitation outcomes suggesting that adults with tetraplegia and co-occurring TBI or paraplegia and mild-moderate TBI achieve similar FIM motor outcomes to SCI peers without TBI.[7] Participants with dual diagnosis in the current study had a high proportion of severe TBI (two-thirds) and achieved comparable FIM motor and cognitive outcomes to their SCI peers without TBI. In this aspect, the findings of the current study contrast with Macciocchi et al's findings and others who have reported lower FIM motor and cognitive scores in adults with dual diagnosis compared to single diagnosis SCI[5] at completion of acute rehabilitation. Differences in stage of recovery (acute vs inpatient rehabilitation) and length of stay may account for these differing results. Initial differences that are evident during acute rehabilitation have been shown to diminish during inpatient rehabilitation as reported by Bradbury et al[6] and confirmed in the present larger study. Further confirmation of group similarity was evident at interview (on average 3.6 years after rehabilitation discharge), at which point SCI and dual diagnosis groups did not differ on FIM motor or cognitive performance.

Furthermore, findings from this study suggest a pattern of recovery in adults with dual diagnosis that is influenced less by cognitive impairment than previously assumed. The dual diagnosis and SCI groups achieved comparable FIM cognitive scores throughout rehabilitation, and these scores were significantly higher than FIM cognitive scores achieved by the TBI group. This finding is particularly surprising as the dual diagnosis and TBI groups were very closely matched on GCS and PTA duration, therefore differences in FIM cognitive scores were not anticipated. This pattern of cognitive recovery persisted to the time of interview, with the dual diagnosis group achieving FIM cognitive scores comparable to the SCI group and slightly higher than the TBI group.

Differences between the dual diagnosis and TBI groups may be related to significantly different lengths of acute and rehabilitation hospital admissions. Participants with dual diagnosis (and single diagnosis SCI) experienced an acute admission 61 days longer than TBI peers and a rehabilitation admission 117 days longer than TBI participants, totalling an additional 6 months of hospital admission. The observed difference in length of rehabilitation stay appears to be an institutional factor; the SCI and dual diagnosis groups (who received rehabilitation from the same facility) reported similar length of rehabilitation admission whereas the TBI group (who received rehabilitation at a different facility) received a significantly shorter length of stay, even in the presence of similar levels of disability. This additional time, particularly in rehabilitation, may be the most plausible factor to explain the capacity for adults with dual diagnosis to gain comparable functional outcomes through an extended opportunity to learn adaptive and compensatory techniques prior to community discharge. It is important therefore to consider that the findings of this study may not generalize to facilities that do not offer comparable levels of extended rehabilitation admission.

Previous findings that identified greater resource use by people with dual diagnosis[6] were not supported by the findings of this study. Participants with dual diagnosis received similar levels of care and support to participants with SCI. TBI participants reported receiving less care and support. Participants with SCI, on average, reported being able to be left alone for a few days (CANS level 3), whereas participants with dual diagnosis, on average, indicated an ability to be left alone for almost a week (CANS level 2). In contrast, the TBI participants, on average, indicated an ability to live alone, needing less than weekly contact (CANS level 1). The level of care provided did not always meet the needs of participants. It was clear from comments made by study participants that knowledge about available services and processes for accessing these services varied between individuals. It is unclear whether the above described level of care reflects the current available care or the true need of each individual. Further, the type of care received by groups varied. Participants with TBI tended to request assistance with communication needs and home and community activities, whereas the SCI and dual diagnosis groups required assistance with personal care tasks such as bathing, feeding, transfers, and continence management in addition to home and community activities. In contrast to previously published studies of the care and needs of adults with TBI, the current cohort was more independent and reported using less support services.[29] However, Soo et al's study cohort were assessed an average of 2.7 years post injury,[29] compared to 3.6 years in the current study. It is therefore possible that this finding may indicate a progressive reduction over time in the need for regular care and support as individuals become more adaptive or use more efficient compensatory systems that reduce their need for regular care.

Mood and behavior changes were minimal across the 3 groups. The additional effect of brain injury in participants with dual diagnosis did not lead to the hypothesized increase in symptoms of stress, anxiety, depression, or overt behavior changes. Stress, anxiety, and depressive symptoms were in fact lowest in the dual diagnosis group. It is unclear at present why this group of dual diagnosis participants demonstrated higher than expected levels of adaptive behavior. A potential area of future research may include investigation of resilience in this clinical population and the relationship between extended length of rehabilitation admission and better adaptive mechanisms to support community-based living. Depression and anxiety are negative correlates of resilience in young people with TBI and non-TBI controls[30]; further, structural equation modelling of adults with SCI demonstrates a clear negative relationship among stress, depression, and resilience.[31] It is possible that resilience may play a significant part in facilitating the functional recovery of this concomitant TBI/SCI group.

The final hypothesis that participants with dual diagnosis would experience poorer community integration was also not supported. In fact, all 3 groups achieved very similar levels of community participation as suggested by the SPRS. The scores achieved by all groups on the SPRS exceeded scores previously published for adults with TBI[32] and were similar to previously reported SPRS scores for adults with SCI living in the community.[33] Employment in this study adopted a wider view of productive engagement including paid work, volunteer work, and study. The level of productive engagement reported was greater than previous studies that have used a similar broad definition with adults who have SCI[34] and adults with TBI.[35] Adults with TBI reported the lowest level of productive engagement (37%), whereas adults with dual diagnosis reported the highest level (63%). Environmental barriers as measured by the CHIEF did not appear to mediate the relationship between diagnosis and employment, as all groups reported similar barriers that were low in comparison to previous studies of adults with SCI and TBI.[36]

This research presents an unexpected view of adults with concomitant TBI and SCI; they appear to be recovering to a level comparable to their SCI single diagnosis peers. These findings extend the work of previously reported studies[5-7] to provide a longitudinal view of people with TBI, SCI, and dual diagnosis several years following rehabilitation discharge. There were many strengths of this study that increase the external validity of the findings. First, participants were recruited from metropolitan and rural areas, with a representative spread of injury severity from mild to severe. Second, dual diagnosis participants were thoroughly matched on an individual case-by-case basis to participants with a single diagnosis of TBI or SCI on multiple demographic and injury characteristics. Potentially confounding variables were also examined. Previous studies have case-matched participants on injury level but have group-matched on other variables, including age and sex.[2,5,6] Third, this study is the only published case-matched study to include a TBI group (existing studies have only compared dual diagnosis to SCI).

Despite these strengths, this study was not without limitations. The sample size was relatively small and may have reduced the ability to detect between-group differences when comparing several outcome variables. Furthermore, participant self-reports may contribute to over- or underestimates in terms of response accuracy, depending on the level of insight of each participant. However, any effect in this regard needs to be balanced against the advantage of gaining a clear perception of the participants' experience of how the injury has impacted their lives. Finally, the cross-sectional design of the study, while providing a snap-shot of individuals at a single point in time, would be strengthened by future prospective longitudinal studies.

## Conclusion

Adults with dual diagnosis achieved a comparable or better level of medical, psychological, and functional recovery and employment and community participation as their single diagnosis SCI and TBI peers. Adults with dual diagnosis reported higher than anticipated levels of independence and productivity and few changes to mood and behavior. The contribution of rehabilitation factors, such as longer admission time to develop compensatory techniques and strategies for adaptation in the community, may have contributed to these positive findings.

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## REFERENCES

1. Macciocchi SN, Seel RT, Thompson N, Byams R, Bowman B. Spinal cord injury and co-occurring traumatic brain injury: Assessment and incidence. *Arch Phys Med Rehabil.* 2008;89:1350-1357.
2. Michael DB, Guyot DR, Darmody WR. Coincidence of head and cervical spine injury. *J Neurotrauma.* 1989;6:177-189.
3. Bowman B, Macciocchi SN. Dual diagnosis: Diagnosis, management, and future trends. *Top Spinal Cord Inj Rehabil.* 2004;10:58-68.
4. Granger C, Hamilton B, Sherwin F. *Functional Independence Measure.* Buffalo, NY: Uniform Data System for Medical Rehabilitation; 1986.
5. Macciocchi SN, Bowman B, Coker J, Apple D, Leslie D. Effect of co-morbid traumatic brain injury on functional outcome of persons with spinal cord injuries. *Am J Phys Med Rehabil.* 2004;83:22-26.
6. Bradbury CL, Wodchis WP, Mikulis DJ, Pano EG, Hitzig SL, McGillivray CF, Ahmad FN, Craven BC, Green RE. Traumatic brain injury in patients with traumatic spinal cord injury: Clinical and economic consequences. *Arch Phys Med Rehabil.* 2008;89:S77-84.
7. Macchioochi S, Seel RT, Warshowsky A, Thompson N, Barlow K. Co-occurring traumatic brain injury and acute spinal cord injury rehabilitation outcomes. *Arch Phys Med Rehabil.* 2012;93:1788-1794.
8. Arzaga D, Shaw V, Vasile A. Dual diagnosis: The person with a spinal cord injury and a concomitant brain injury. *SCI Nurs.* 2003;20:86-92.
9. Richards JS, Osuna FJ, Jaworski TM, Novack TA, Leli DA, Boll TJ. The effectiveness of different methods of defining traumatic brain injury in predicting postdischarge adjustment in a spinal-cord injury population. *Arch Phys Med Rehabil.* 1991;72:275-279.
10. Whiteneck G, Gerhart KA, Cusick CP. Identifying environmental factors that influence the outcomes of people with traumatic brain injury. *J Head Trauma Rehabil.* 2004;19:191-204.
11. Price P, Stephenson S, Krantz L, Ward K. Beyond my front door: The occupational and social participation

of adults with spinal cord injury. *OTJR Occup Particip Health.* 2011;31:81-88.
12. Whiteneck G, Meade MA, Dijkers M, Tate DG, Bushnik T, Forchheimer MB. Environmental factors and their role in participation and life satisfaction after spinal cord injury. *Arch Phys Med Rehabil.* 2004;85:1793-1803.
13. Callaway L, Sloan S, Winkler D. Maintaining and developing friendships following severe traumatic brain injury: Principles of occupational therapy practice. *Austral Occup Ther J.* 2005;52:257-260.
14. Devitt R, Colantonio A, Dawson D, Teare G, Ratcliff G, Chase S. Prediction of long-term occupational performance outcomes for adults after moderate to severe traumatic brain injury. *Disabil Rehabil.* 2006;28:547-559.
15. Sherman JE, DeVinney DJ, Sperling KB. Social support and adjustment after spinal cord injury: Influence of past peer-mentoring experiences and current live-in partner. *Rehabil Psychol.* 2004;49:140-149.
16. Winkler D, Unsworth C, Sloan S, Winkler D, Unsworth C, Sloan S. Factors that lead to successful community integration following severe traumatic brain injury. *J Head Trauma Rehabil.* 2006;21:8-21.
17. Huebner RA, Johnson K, Bennett CM, Schneck C. Community participation and quality of life outcomes after adult traumatic brain injury. *Am J Occup Ther.* 2003;57:177-185.
18. Jennett B, Teasdale G. Aspects of coma after severe head injury. *Lancet.* 1977:878-881.
19. American Spinal Injury Association. *International Standards for Neurological and Functional Classification of Spinal Cord Injury Patients.* Chicago: Author; 2000.
20. Shores EA, Marosszeky JE, Sandanam J, Batchelor J. Preliminary validation of a clinical scale for measuring the duration of post-traumatic amnesia. *Med J Austral.* 1986;144:569-572.
21. Gronwall D, Wrightson P. Duration of post-traumatic amnesia after mild head injury. *J Clin Neuropsychol.* 1980;2:51-60.
22. Seekins T. *Beyond Disability, Consumer Reporting Form, Secondary Condition Prevention Program.* Montana: University of Montana; 1990.
23. Lovibond SH, Lovibond PF. *Manual for the Depression, Anxiety, Stress Scales.* Sydney, Australia: Psychology Foundation of Australia; 1995.
24. Kelly G, Todd J, Simpson G, Kremer P, Martin C. The Overt Behaviour Scale (OBS): A tool for measuring challenging behaviours following ABI in community settings. *Brain Inj.* 2006;20:307-319.
25. Tate RL. Assessing support needs for people with traumatic brain injury: The Care and Needs Scale (CANS). *Brain Inj.* 2004;18:445-460.
26. Tate RL, Hodgkinson A, Veerabangsa A, Maggiotto S. Measuring psychosocial recovery after traumatic brain injury: Psychometric properties of a new scale. *J Head Trauma Rehabil.* 1999;14:543-557.
27. Kettl P, Hershey M. Sexuality after spinal cord injury questionnaire. In: Davis C, Yarber W, Bauserman R, Schreer G, Davis S, eds. *Handbook of Sexuality-Related Measures.* 2nd ed. Thousand Oaks, CA: Sage Publications; 1998:179-181.
28. Harrison-Felix C. The Craig Hospital Inventory of Environmental Factors. 2001. The Center for Outcome Measurement in Brain Injury. *http://www.tbims.org/combi/chief*. Accessed April 8, 2009.
29. Soo C, Tate RL, Aird V, Allaous J, Browne S, Carr B, Coulston C, Diffley L, Gurka J, Hummell J. Validity and responsiveness of the Care and Needs Scale for Assessing Support Needs After Traumatic Brain Injury. *Arch Phys Med Rehabil.* 2010;91:905-912.
30. Tonks J, Yates P, Frampton I, Williams WH, Harris D, Slater A. Resilience and the mediating effects of executive dysfunction after childhood brain injury: A comparison between children aged 9-15 years with brain injury and non-injured controls. *Brain Inj.* 2011;25:870.
31. Catalano D, Chan F, Wilson L, Chiu C-Y, Muller VR. The buffering effect of resilience on depression among individuals with spinal cord injury: A structural equation model. *Rehabil Psychol.* 2011;56:200-211.
32. Kuipers P, Kendall M, Fleming J, Tate R. Comparison of the Sydney Psychosocial Reintegration Scale (SPRS) with the Community Integration Questionnaire (CIQ): Psychometric properties. *Brain Inj.* 2004;18:161-177.
33. De Wolf A, Lane-Brown A, Tate RL, Middleton J, Cameron ID. Measuring community integration after spinal cord injury: Validation of the Sydney psychosocial reintegration scale and community integration measure. *Qual Life Res.* 2010;19:1185-1193.
34. Engel S, Murphy GS, Athanasou JA, Hickey L. Employment outcomes following spinal cord injury. *Int J Rehabil Res.* 1998;21:223-229.
35. Yasuda S, Wehman P, Targett P, Cifu D, West M. Return to work for persons with traumatic brain injury. *Am J Phys Med Rehabil.* 2001;80:852-864.
36. Whiteneck G, Harrison-Felix CL, Mellick DC, Brooks CA, Charlifue SB, Gerhart KA. Quantifying environmental factors: A measure of physical, attitudinal, service, productivity, and policy barriers. *Arch Phys Med Rehabil.* 2004;85:1324-1335.
37. Corrigan JD, Selassie AW, Oman JA. The epidemiology of traumatic brain injury. *J Head Trauma Rehabil.* 2010;25:72-80.